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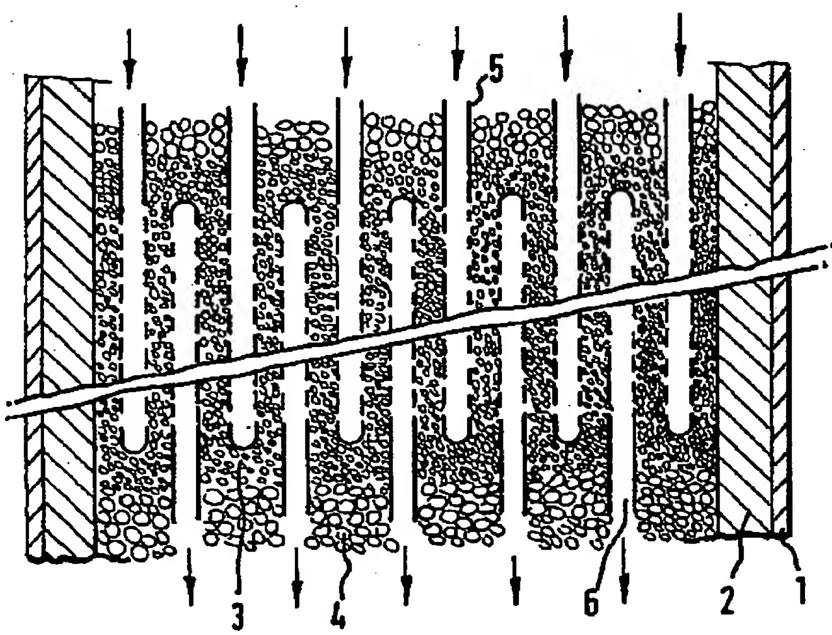
(54) Fixed bed reactor.

(57) Fixed bed reactor for operation at very high temperatures and high space velocities, e.g. for catalytic partial oxidation or a catalytic treatment of the product gas from a non-catalytic partial oxidation of a hydrocarbonaceous feedstock.

The fixed bed (3) of catalyst contains parallel tubes (5,6) serving to conduct feed to within the bed and to conduct product out of the bed. The tubes are closed at one end and are provided with slits or holes to allow passage of feed/product but too small to allow entrance of catalyst particles. The feed passes the catalyst bed in a transverse direction from inlet tube to outlet tube.



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FIXED BED REACTOR

The present invention relates to a fixed bed reactor for carrying out processes at very high temperatures and high space velocities, e.g. a catalytic partial oxidation process of a hydrocarbonaceous feedstock, or a catalytic treatment of the product gas from a non-catalytic partial oxidation of a hydrocarbonaceous feedstock.

Catalytic partial oxidation of natural gas is an attractive route for producing synthesis gas for further conversion to hydrocarbons or methanol. In this process a mixture of natural gas and an oxygen-containing gas (e.g. oxygen, air or steam-diluted oxygen) is passed over a suitable catalyst at elevated temperature. The ideal process would operate at very high temperatures (above 1000 °C for thermodynamic reasons) and at elevated pressure (30 bar and higher) and very high space velocities (e.g. 100,000 Nl/l.h.). At these very high space velocities pressure drop becomes an important factor. It has already been proposed to use a reactor in which the catalyst is in the form of a monolith (honeycomb) which features a low pressure drop at the very high space velocities applied. Although this reactor concept is an attractive one, it will not be easy to scale it up to very large sizes. Fabrication of monoliths of very large size may require further developments in ceramics fabrication technology while the positioning and fixing of the monoliths in the reactor space has to meet the demands on mechanical and thermal stresses. At very high temperatures, where normal metals may no longer be used and at very large scales this is not an easy matter. Monoliths known at present are made mostly of cordierite, which under practical conditions cannot be used anymore above some 1100 °C while ideally one would like a catalytic system operable up to some 1300 °C.

The use of a fixed bed of catalyst particles in principle allows more freedom of choice between heat-resistant catalyst support materials. However, to avoid unduly high pressure drops, one has to resort to shallow beds. An example is a shallow bed in a spherical reactor, which however implied rather poor use of the reactor space. Other examples are cylindrical reactors in which the reactant flows laterally instead of longitudinally, e.g. a flat bed parallel to the central axis or a radial flow reactor. Such shallow beds imply a large cross-sectional area. To properly support such very wide beds using constructional materials which can resist temperatures of the order of 1200 °C is not easy, however.

In non-catalytic processes for making synthesis gas, a hydrocarbon feedstock such as natural gas or heavy oil is partially oxidized in a burner placed inside a pressure vessel. Well-known processes of this type are the Texaco partial oxidation process and the Shell Gasification Process (SGP). The oxidation reactions take place non-catalytically in the flame zone at very high temperature, typically some 1800 °C. The reaction gas leaving the partial oxidation vessel typically has a temperature of 1200 °C and higher and is cooled down in a waste heat boiler. Higher yields of synthesis gas may be obtained by contacting the gas with a catalyst to allow endothermic reactions to occur between unconverted hydrocarbons and steam and/or carbon dioxide (which are present as products of combustion or added to the feed as moderating agents). In addition to the enhanced process efficiency by the improved synthesis gas yields, this catalytic treatment also has the advantage that synthesis gas with a more optimum H_2/CO ratio may be produced for synthesis of hydrocarbons or methanol and that it allows simultaneous removal of contaminants in the product gas of the non-catalytic partial oxidation process (e.g. HCN, carbonaceous compounds, etc.). However, a problem is that the catalytic treatment, like in the previous application, has to be done at a high temperature level (in the range 1000-1400 °C) with very low pressure drop. Known catalytic reactors when used for this purpose have similar problems as mentioned above.

It is an object of the invention to provide a fixed bed reactor with low pressure drop suitable for operation at very high temperatures which avoids these problems.

It is another object of the invention to provide such a reactor having a simple construction from heat resistant components and possibilities for scaling up.

The invention therefore provides a reactor for carrying out a catalytic partial oxidation process of a hydrocarbonaceous feedstock or for catalytic treating of the product gas from non-catalytic partial oxidation of such a feedstock, characterized by means for providing a mixture of hydrocarbonaceous feedstock, oxygen-containing gas and, optionally, steam or the product resulting from non-catalytic reaction of this mixture to a catalytic reaction zone and means for discharging the product gas, comprising a first arrangement of parallel inlet tubes in a fixed catalyst bed in order to supply the feed to within the bed and a second arrangement of parallel outlet tubes in order to withdraw the product from the bed, wherein the tubes are closed at their one end and have openings to allow passage of reactant or product, but not of catalyst particles and wherein the feed passes the catalyst bed in a transverse direction from inlet tube to

outl t tube.

The invention will n w be described in more detail by way of example by reference to the accompanying drawing, in which the figure represents a partial transverse section of a low pressure drop, high temperature fixed bed reactor of the invention. Referring now to the figure, a reactor having a (steel) wall 1 is shown. The (steel) wall 1 has been provided with any insulation 2 suitable for the purpose. The reactor is advantageously cylindrical.

A fixed catalyst bed 3 is present within the reactor. The manner in which a fixed bed can be maintained in a reactor, is known to those skilled in the art and will not be described in detail. Further coarse ceramic packing 4 is present.

In the fixed bed a first set of parallel inlet tubes 5 is present to supply the feed to within the bed. A second set of parallel outlet tubes 6 is present to withdraw the product from the bed. In the figure the said first set consists of six inlet tubes whereas the said second set consists of five outlet tubes. However, it will be appreciated that any number of tubes suitable for the purpose can be applied.

The tubes are closed at one end and have openings to allow passage of reactant or product, but not of catalyst particles. The feed passes the catalyst bed in a transverse direction from inlet tube to outlet tube. These openings can be slits (e.g. made by sawing) or small holes (e.g. made by drilling). The tubes may be made of heat-resistant (ceramic) material such as alumina or silicon carbide. If the length required exceeds the possibilities of the fabrication technology, they can be made up from sections jointed together with a rather loose joint. Such a jointed tube may have the additional advantage of being less vulnerable to breakage as a result from thermal workings of the catalyst bed.

The positioning of the tubes inside the bed may involve the use of spacers, e.g. in the form of ceramic rings which keeps the tubes apart at appropriate distances. However, it may well be possible to rely on the catalyst bed itself to position the tubes. In the latter case one only has to ensure a temporary fixing of the tubes during the filling operation.

Particularly in the latter case the construction of the reactor would seem to be very simple and may result in a cheap system. The scaling up capability of this type of reactor is very good.

In an advantageous embodiment of the invention the tubes have a total length of 3 m (made up from sections of 1 m), an outer diameter of 5 cm and an inner diameter of 4 cm, whereas the reactor has a length of 4 m and a diameter of 2 m. Advantageously th slits or th small holes have the following dimensions: 1 mm width, 2 cm l ngth, or 2 mm diameter.

The inlet as well as the outlet tubes can be arranged advantageously in a regular pattern, e.g. a square or triangular array with a pitch of 5-15 cm. The array of outlet tubes is such, that each outl t tube is in the centre of the squares or triangles formed by the centres of the neighbouring inlet tube. The space between the tubes is filled with catalyst of suitable form, e.g. spheres of 2.5 - 4 mm, extrudates of 1.0 - 3.0 mm diameter and 2 - 6 mm length.

Various modifications of the invention will become apparent to those skilled in the art from the foregoing description and accompanying drawings. Such modifications are intended to fall within the scope of the appended claims.

Claims

1. A reactor for carrying out a catalytic partial oxidation process of a hydrocarbonaceous feedstock or a catalytic treatment of the product gas from a non-catalytic partial oxidation of a hydrocarbonaceous feedstock characterized by means for providing a mixture of hydrocarbonaceous feedstock, oxygen-containing gas and, optionally, steam or the product gas resulting from non-catalytic reaction of this mixture to a catalytic reaction zone and means for discharging the product gas, comprising a first arrangement of parallel inlet tubes in a fixed catalyst bed in order to supply the feed to within the bed and a second arrangement of parallel outlet tubes in order to withdraw the product from the bed, wherein the tubes are closed at their one end and have openings to allow passage of reactant or product, but not of catalyst particles and wherein the feed passes the catalyst bed in a transverse direction from inlet tube to outlet tube.

2. The reactor as claimed in claim 1 characterized in that the reactor is cylindrical.

3. The reactor as claimed in claim 1 or 2 characterized in that the openings are slits.

4. The reactor as claimed in claims 1 or 2 characterized in that the openings are small holes.

5. The reactor as claimed in any one of claims 1-4 characterized in that the tubes are made of heat-resistant material.

6. The reactor as claimed in claim 5 characterized in that the tubes are made of alumina.

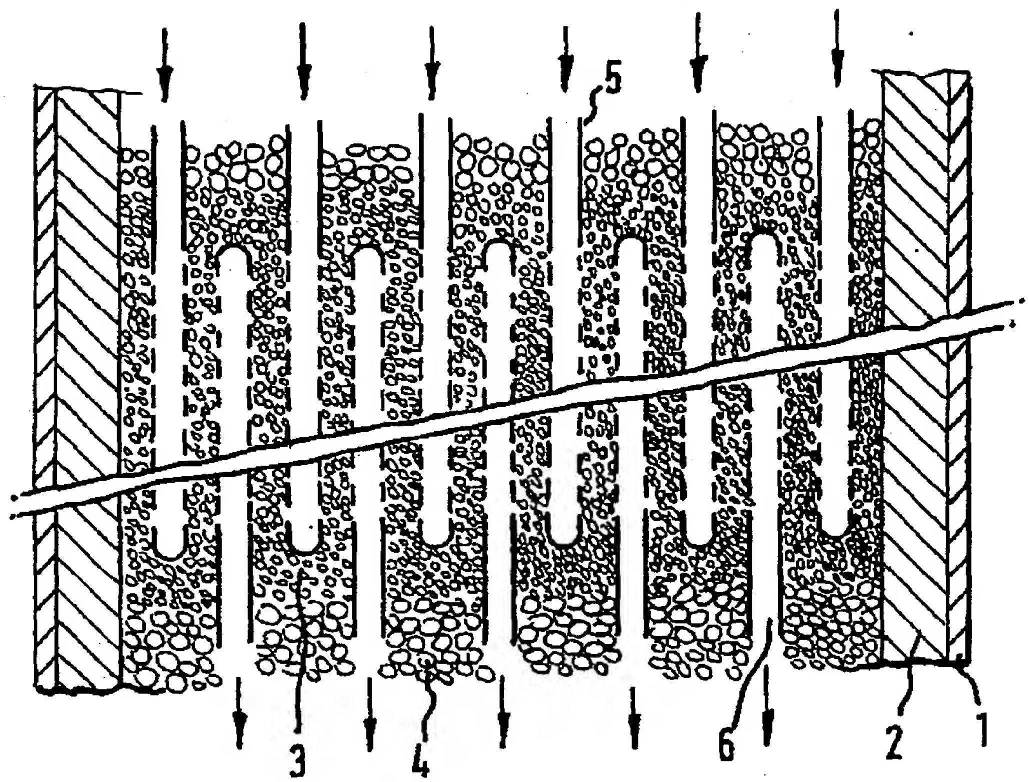
7. The reactor as claimed in claim 5 characterized in that the tubes are made of silicon

carbide.

8. Th reactor as claimed in any one of claims 1-7 characterized in that th tubes are made up from sections jointed together with a loose joint.

9. The reactor as claimed in any one of claims 1-8 characterized in that the tubes are positioned inside the fixed bed by spacers..

10. The reactor as claimed in claim 9 characterized in that the spacers are ceramic rings.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EUROPEAN SEARCH REPORT

Application Number

EP 90 20 3481

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	US-A-2 942 958 (J.B. DWYER) * Column 1, lines 15-19,47-63; column 2, line 18 - column 6, line 33; column 6, lines 39-50; figures 1,2 *	1	B 01 J 8/02 C 01 B 3/38
Y	US-A-2 108 087 (C.H. THAYER) * Page 1, column 1, lines 1-42; page 2, column 1, lines 23-54; figure 1 *	1	
A		2,4,5	
A	US-A-1 987 904 (E.J. HOUDRY) * Page 1, column 1, lines 21-32; page 3, column 1, lines 7-33; figures 1,5-7 *	1-3	
A	US-A-2 108 069 (R.C. LASSIAT) * Page 1, column 1, lines 1-19; page 1, column 2, line 33 - page 2, column 1, line 2; page 2, column 1, line 71 - column 2, line 4; figures 1,3 *	1,2,4,9	
A	US-A-3 477 824 (R.D. REED) * Abstract; column 1, lines 21-60; column 2, line 19 - column 3, line 43; figure 1 *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

B 01 J
C 01 B

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	07 May 91	SIEM T.D.

CATEGORY OF CITED DOCUMENTS

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